(2)

SEDIMENT TRANSPORT EVENTS ON SLOPES AND SHELVES (STRESS)

Arthur R.M. Nowell

School of Oceanography, WB-10
University of Washington
Seattle, WA 98195
(206) 685-0923

JULY 1992

Robert A. Wheatcroft

Applied Ocean Physics & Engineering Department
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
(508) 457-2000 ext. 3427

Long-Range Scientific Objectives

In the general study of benthic processes an important set of unknowns exists concerning interactions between the bed and the flow field. The local geometry of the bed in part controls the structure of the bottom boundary layer, but the bed geometry itself is also in part controlled by the flow. Benthic organisms complicate the problem further. Our long-range research objectives are to understand the various interactions between sediments, flow and organisms in sufficient detail to permit predictions regarding the relative importance of various processes in different environments. Our approach is an iterative one between theory and field measurements.

Project Objectives

The proximate objectives of this research are to: (1) document the temporal variation in microtopography of a silt-bottom (90 m STRESS site, northern California shelf) that is most often influenced solely by biological processes, but is episodically modified by physical sediment transport events, (2) determine the recovery time required for biological reworking to erase physically generated bedforms, (3) measure absolute erosion and deposition amounts following sediment transport events, and (4) compare measured time-series of biological and physical roughness to predictions based on combined wave-current bottom boundary models that are forced using current velocity profiles and wave data.

Present Status and Progress During the Current Year

A stereocamera tripod that was deployed in November 1990 at the 90 m (C3) STRESS site was successfully recovered in mid-March 1991. Stereophotographs of a 40 by 60 cm area of the sea bottom were taken at a 12 hr interval for approximately 90 d. High-resolution (< 1 mm) measurements of bottom microtopography are being made using a calibrated stereocomparator and close-range photogrammetric techniques.

During the deployment five qualitatively different bed configurations were observed. In order of decreasing frequency these were: (1) biogenically reworked bed, (2) smoothed to scoured bed, (3) current-rippled bed, (4) scour-pitted bed, and (5) isobath parallel bedforms. Bed configurations 2 and 4 may be genetically related and only indicative of differing magnitudes of erosion. Flow directions for the physical bed configurations were approximately parallel to the local isobaths, with the current ripples always indicative of poleward flow to the NW, whereas the scour-pitted bed always indicated equatorward flow to the SE. Flow directions of the smoothed to scoured bed were variable.

Initial results from the photogrammetry indicate that total vertical bed relief within the field of view is always less than 6 cm and that the root-mean-square relief is of order 1 cm. Maximal relief occurs when the bed is current rippled (heights average 2 cm and lengths are about 15 cm) and is minimal following scour events. Biological reworking visually destroys the physical bed forms in 1-2 days, but low frequency relief persists for much longer. Because the recurrence interval of bottom erosion at the 90 m STRESS site is of order 1 week during the winter, biological reworking does not return the bed to a pre-storm equilibrium condition as is probably the case in deep-water environments (e.g., HEBBLE).

Future efforts will be directed toward statistical characterization of the bottom roughness. Various tribological indices are being applied to examples of different bed configurations in order to classify seafloor microrelief. Finally, within the larger context of the STRESS project it is of interest whether or not the flow "feels" the fairly small changes in the bed geometry that we measure optically. To address this issue measured time-series of bottom roughness will be compared to predicted time-series of physical roughness that are obtained from combined wave-current bottom boundary models that are forced using current velocity profiles and wave data. The source of these last data are from colleagues in the STRESS project: Williams, Gross and Trowbridge.

Papers and Abstracts

Wheatcroft, R.A. 1991. Quantitative changes in bottom roughness at the mid-shelf STRESS site in relation to bed configuration. *EOS, Trans. Am. Geophys. Union*, 72: 245 (Abstract).

Wheatcroft, R.A. in preparation. A time-series of geometrical bottom roughness at the mid-shelf STRESS site: The contrasting roles of physics and biology. for *Continental Shelf Research*.

Wheatcroft, R.A. and J.H. Trowbridge. in preparation. A comparison between measured and predicted bottom roughness during the STRESS-2 experiment. for *Journal of Geophysical Research*.

STORM-INDUCED SEDIMENT TRANSPORT ON THE CONTINENTAL SHELF

Richard W. Sternberg

School of Oceanography WB-10
University of Washington
Seattle, Washington 98195
(206) 543-0589

Long-Range Scientific Objective

This research is one component of the Sediment Transport Events on Shelves and Slopes (STRESS) program, the objective of which is to study sediment transport caused by winter storms on the continental shelf.

Project Objectives

The objectives of this component of the STRESS program are to make near-bottom measurements of suspended-sediment concentrations over a range of winter-storm conditions and to compare the measurements with models of shelf sediment transport. An additional goal of the field experiment was to provide physical and optical measurements of suspended-sediment concentrations to compare with optical and acoustic measurements made by other STRESS researchers.

Progress In Fiscal Year 1991

The STRESS2 field experiment was conducted in FY91 at the site of the Coastal Ocean Dynamics Experiment (CODE) on the northern California continental shelf. The experiment consisted of two deployments beginning in December, 1990 and ending in March, 1991. Several instruments were successfully deployed and recovered, and an excellent data set was obtained. A brief discussion of the instruments, measurements, and initial analysis of the data follows.

The spatial-temporal sediment sampler (STSS) was deployed on the benthic acoustic stress sensor (BASS) tripod at the 90-m site. STSS was designed to measure the suspended-sediment field, and included six optical backscatter sensors (OBS), an acoustic altimeter, and a data logger. A communications link with the BASS data logger allowed simultaneous burst measurement of currents and sediments. A complete data set of hourly OBS measurements was obtained, each consisting 672 1-Hz samples at each sensor (Figure 1).

A redesigned remote optical settling tube (ROST) was deployed on the acoustic-backscatter sediment-sensor (ABSS) tripod, also at the 90-m site, to measure suspended-sediment settling rates. The device used a 25-cm pathlength transmissometer to estimate sediment concentrations in a 1-m high box. The ends of the box were opened for six hours each day to permit water with ambient sediment concentrations to enter, and closed for 18 hours for settling measurements. Transmissometer measurements and the output of a broad-spectrum light sensor were recorded in a connected data logger. Transmissometer and light readings were recorded for the entire STRESS2 experiment, and the mechanism controlling the box doors operated for 10-15 days at the beginning of each deployment, providing 20-30 individual in situ estimates of particle settling velocities.

A computer-controlled smart pump sampler (SPS) was also deployed on the ABSS tripod. The SPS included two systems for pumping four suspended-sediment samples through intake nozzles mounted 22 and 235 cm above the bottom. Two OBS sensors were mounted at the same elevations and provided optical estimates of suspended-sediment concentration. Two complete time-series of OBS data and a nearly complete suite of pumped samples were obtained from the SPS during both deployments. Because the computer-controlled sampling schedule was calibrated for the higher suspended sediment events measured during the STRESS1 experiment, all of the pumped samples were obtained during times of relatively low concentration.

Initial analysis of the STRESS2 data confirms two observations made by previous investigators: 1) sediment resuspension at the mid-shelf sites is caused primarily by wave activity and mean currents seldom cause resuspension, but 2) sediment transport is controlled by mean currents and is predominantly alongshore and to the north. Preliminary analysis of BASS data and STSS concentration profiles are generally consistent with a steady-state balance between upward diffusion and downward settling of suspended material (Figure 2). These results mean that sediment profiles adjust quickly to changing wave and current conditions, and can be used, in conjunction with estimates of diffusivity profiles, to estimate sediment settling velocities. (Sternberg et al., 1991). Such estimates indicate that settling velocities increased during times of increased wave activity, as did sediment concentrations. The estimates of settling velocity derived from concentration profiles agree favorably with estimates obtained from ROST (Sherwood et al., 1991). Particle-size analysis of pumped samples, ROST data, and other measurement techniques (Lynch et al., 1991) all indicate that the size distribution of suspended-sediment is often bimodal.

Analysis of the data from both STRESS field experiments will be completed in FY92. The OBS data and pumped samples will be compared with measurements made by other STRESS researchers. The time-series and profile data will be compared with results of several numerical models of suspended-sediment transport. Results will be submitted for publication.

Presentations

Lynch, J. F., Y. C. Agrawal, and C. R. Sherwood. 1991. Instrumental Measures of Particle Size and Settling Velocity in STRESS. *EOS Transactions of the American Geophysical Union* 72(44):241.

Sherwood, C. R., Y. C. Agrawal, and J. F. Lynch. 1991. Suspended Sediment Concentration Profile Measurements in STRESS. *EOS Transactions of the American Geophysical Union* 72(44):241.

Sternberg, R. W., C. R. Sherwood, T. F. Gross, and A. J. Williams III. 1991. Suspended-sediment and Concentration Profiles on the Northern California Continental Shelf During STRESS-2. *EOS Transactions of the American Geophysical Union* 72(44):241.

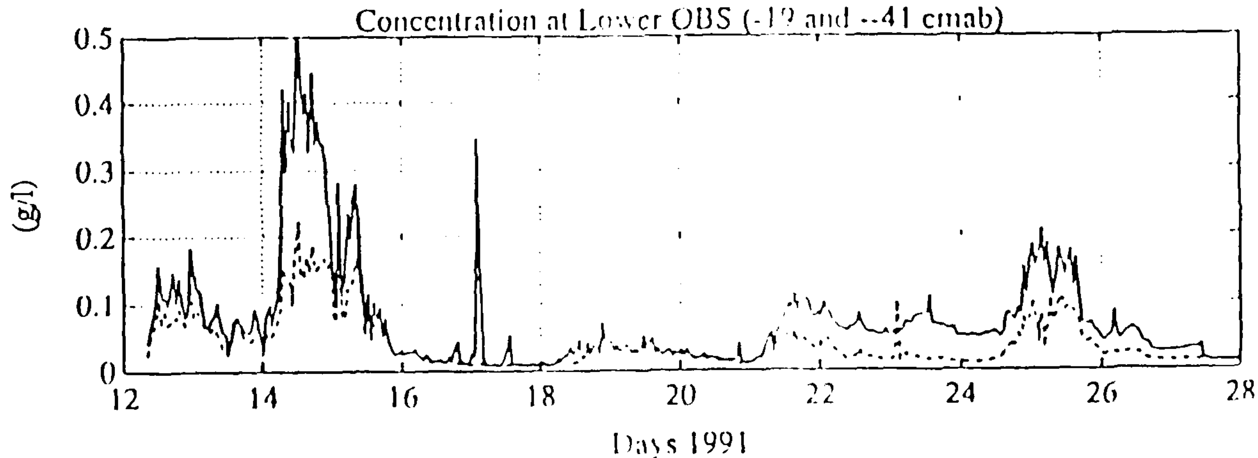

Figure 1. Time series of suspended-sediment concentrations estimated with STSS OBS located 19 and 41 cm above the bed (cmab) at the STRESS 90-m site. Each hourly estimate consists of 672 samples made at 1 Hz.

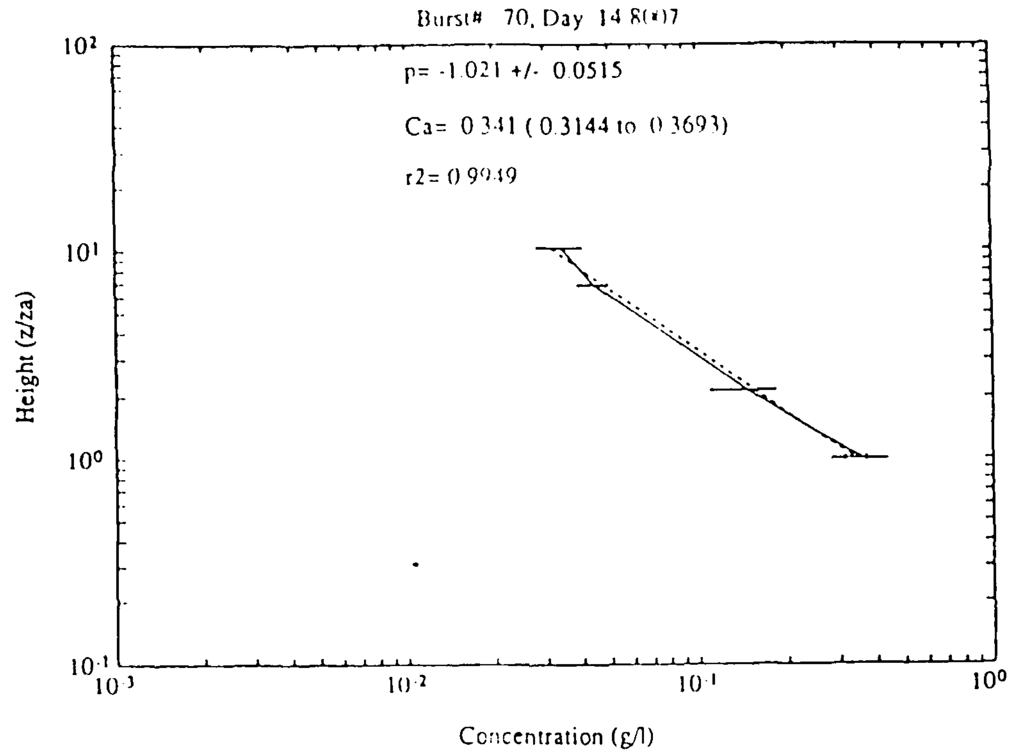

Figure 2. Representative vertical profile of suspended sediments from STSS OBS during the resuspension event of January 14, 1991. Solid line connects data from 4 OBS at 19, 41, 131, and 196 cmab, and shows standard deviation at each elevation. *Dashed line shows least-squares log-log fit, with slope* p = -1.02 *cm* g^{-1} l, intercept C_a = 0.34 *g* l^{-1} at the bottom OBS (z_a = 41 cm), and regression coefficient r^2 = 0.995.